Space Weather Technical Forecast

Issued on Wednesday 2 October 2024 at 13:28 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: R1-R2 Blackouts expected, chance of further R3 Blackouts. Chance of G1/Minor Geomagnetic storm intervals Days 1-2. Chance G2/Moderate Geomagnetic storms Days 3-4.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been High over the past 24 hours, with a X7.1 from AR3842 at 01/2220 UTC as well as a number of M-class flares. Around thirteen sunspot regions are currently on the visible disc. The most notable and largest region remains AR3842, in the southeast quadrant but approaching central disc. This region has shown an increase in magnetic complexity, with growth in the compact central and leading portions and at least one delta spot. The next largest region is newly numbered AR3848 which is currently rotating into view around the northeast limb. The size and classification has been estimated but the viewing angle restricts confidence. AR3841 in the north, close to centre disc, is the next largest spot and is also complex containing two strong delta spots in its trailing portion. AR3843 and AR3844 in the south near centre disc are the remaining spots of note, with both Dsi/Beta regions exhibiting further penumbral growth and the proliferation and consolidation of smaller spots. All other spots are smaller and appear relatively benign.

The X7.1 flare from AR3842 produced a CME. Imagery of this feature is currently being analysed, however, due to the location of the source region, it is likely that there will have been an Earth-directed component.

Solar Wind / Geomagnetic Activity: Solar wind parameters were indicative of a weakening coronal hole fast wind. Speeds were slightly elevated initially, around 420 km/s, but have since eased to slow-ambient speeds of around 350 km/s. Density was below average. The Interplanetary Magnetic Field, Bt, remained at weak levels, below 8nT. The north-south component Bz, remained at weak values below +/-6nT. Phi angle was mostly negative (towards the Sun). Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was at background to moderate levels (at diurnal peak), with a peak value of 222 pfu at 01/1650 UTC. The associated 24-hour fluence was below the Active threshold.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to become Moderate, with further M-class flares expected and a chance of returning to High should another isolated X-class flare occur, these most likely originating from AR3842.

Solar Wind / Geomagnetic Activity: CMEs from 29 Sep and 30 Sep may have glancing impacts at Earth during Day 1 or Day 2 (02 or 03 Oct), however both are considered low confidence and low probability. Of greater significance is the chance of an arrival from the CME associated with the X7.1 flare on 01 Oct. Analysis is currently underway, but rudimentary analysis suggests arrival time later Day 3 or during Day 4 (04/1200 UTC -05/1200 UTC).

Solar wind speeds should remain at largely background during Days 1-2, with slight enhancement possible from any CME enhancement. Elevated wind speeds are possible later in the period following the potential arrival of the CME from 01 Oct.

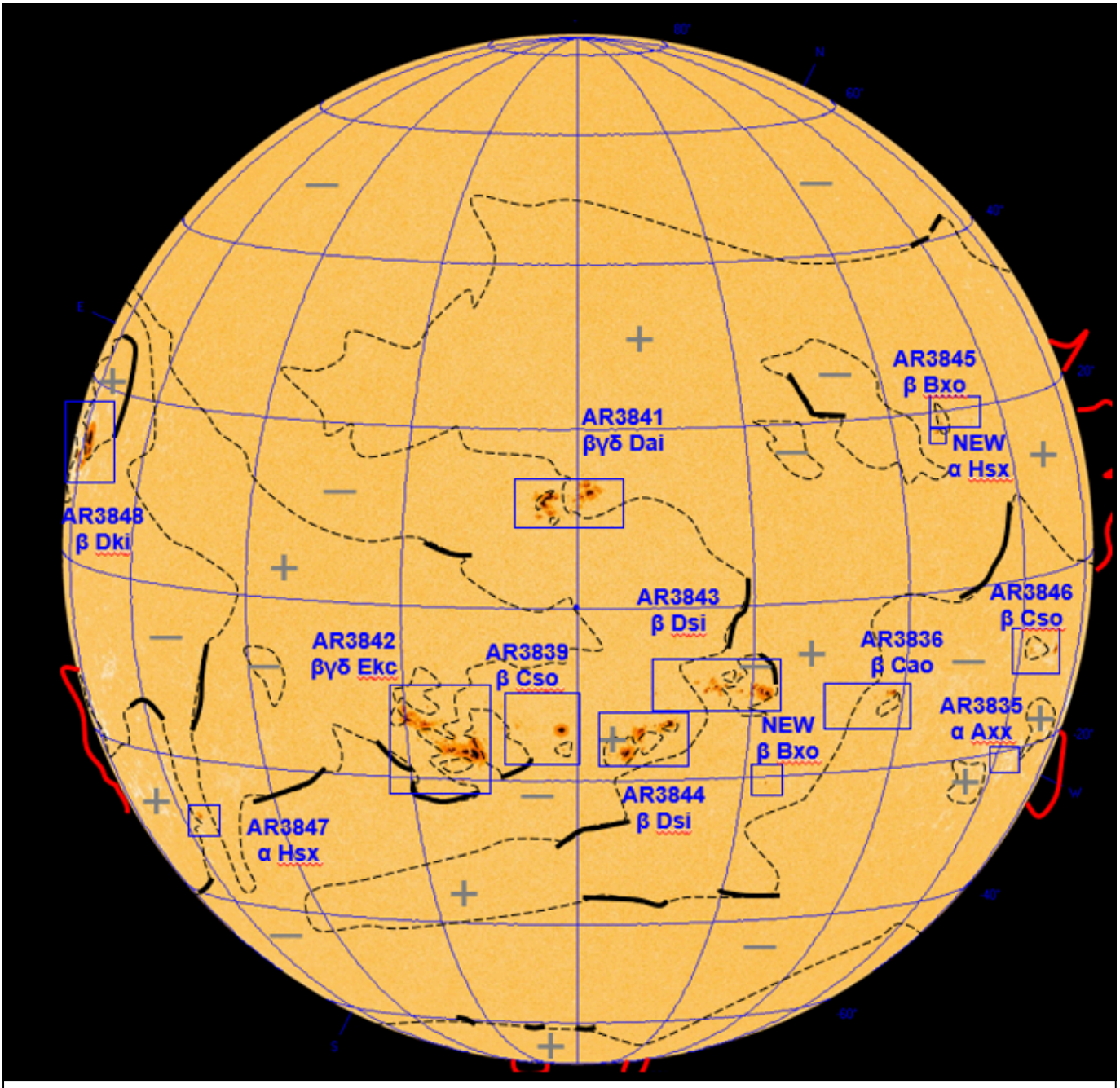
Quiet (Kp 0-2) geomagnetic conditions are expected to prevail during Days 1-2. There is a chance of Active (Kp4) periods or G1/Minor Geomagnetic storm intervals (Kp5) occurring during Days 1-2 (02-03 Oct) due to a possible late glancing blow of the 29 Sep CME or the glancing blow of 30 Sep CME, this risk reducing later day 2 (03 Oct). Later Day 3 and during Day 4 (04-05 Oct) the possibility of the CME arrival sees a likelihood of G1-G2/Minor-Moderate Geomagnetic Storms and a slight chance of G3/Strong Geomagnetic Storm interval should a more direct hit occur.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is forecast to persist at background with a chance of rising above should further significant flares occur. High energy electron flux at GOES16 is expected to persist at Background to Moderate levels with a chance of High levels at diurnal peak later in the period. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 total pfu), throughout.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 1: Synoptic Map valid 02/0800 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Storms

A CME which left the Sun from the southwest quadrant on 29/0544 UTC has been analysed with possible glancing impacts at Earth early Day 1 (02 Oct), but with low confidence in the speed due to lack of STEREO A imagery meaning that this CME may be slower than anticipated. Although the bulk of the CME will miss ahead of Earth's orbit, glancing impacts remain possible. A further CME was observed leaving the Sun around 30/1545 UTC, this fast CME will mostly miss Earth however there is a small chance of a glancing blow either on Day 1 or Day 2 (03 Oct). A CME was seen to the south and southeast of the disc associated with the X7.1 flare on 01/2220 UTC. Subsequent M-flares from the same sunspot region may also have an Earth-directed component. Analysis is currently underway following a lack of LASCO imagery overnight and an absence of STEREO-A imagery entirely. Rudimentary analysis based on radio emissions and the sunspot's location suggests arrival time later Day 3 (04 Oct) or more likely during Day 4 (05 Oct). The arrival window is considered low confidence at this stage and will be updated on later issues of the technical document.

Solar wind speeds have seen a gradual easing trend following waning effects of CH76/-. In the absence of any CME, solar wind speeds should trend remain at background over the next couple of days. Currently solar winds in MOSWOC Enlil are far too high due to Enlil vastly overestimating the longevity of the current coronal hole fast wind by 150-200km/s which may influence arrival times of CMEs in the forecast and any associated increase in wind speeds or geomagnetic response. MOSWOC Enlil and Enlil ensemble currently display a possibility of at least glancing blows from all the aforementioned CMEs. MOSWOC SWPM considered a better steer for wind speeds during the next couple of days, before uncertain CME influence.

Quiet (Kp 0-2) geomagnetic conditions are expected to prevail during Days 1-2. There is a chance of Active (Kp4) periods or G1/Minor Geomagnetic storm intervals (Kp5) occurring during Days 1-2 (02-03 Oct) due to a possible late glancing blow of the 29 Sep CME or the glancing blow of 30 Sep CME, this risk reducing later day 2 (03 Oct). Later Day 3 and during Day 4 (04-05 Oct) the possibility of the CME arrival sees a likelihood of G1-G2/Minor-Moderate Geomagnetic Storms and a slight chance of G3/Strong Geomagnetic Storm interval should a more direct hit occur. It may be that further analysis of the X7 CME reveals a higher likelihood of G3 (Kp 7) or greater, but values are accepted as a reasonable steer at this stage.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	40	60
Strong	G3	No	1	1	15	20
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

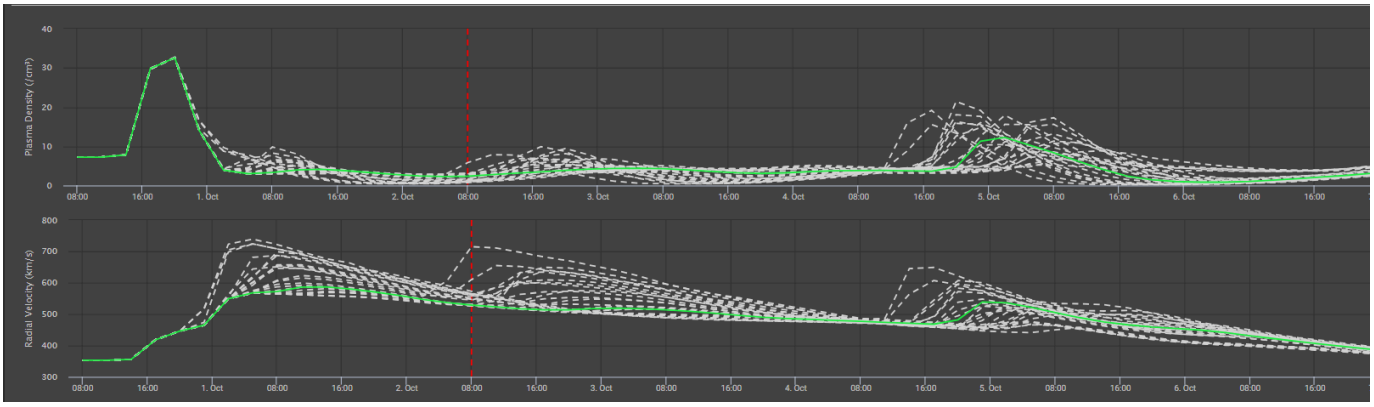
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
29/0901	Partial	AR3834	SW	1200	01/0900UTC	Glancing blow. Low confidence.
30/1545	Partial	Filament	SW	1500	03/0300UTC	Glancing blow. Low confidence.
02/0938	Partial	AR3842	SE	800	04/2300 UTC	Low confidence based on estimates. +/- 12hrs arrival time.

Figure 2: MOSWOC Enlil Ensemble showing a range of possible arrival times for the 29 and 30 Sept CMEs, and for the loosely modelled 01 Oct CME.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 3: MOSWOC Enlil showing potential CME arrivals during the period. Enlil wind speeds considered poor guidance.

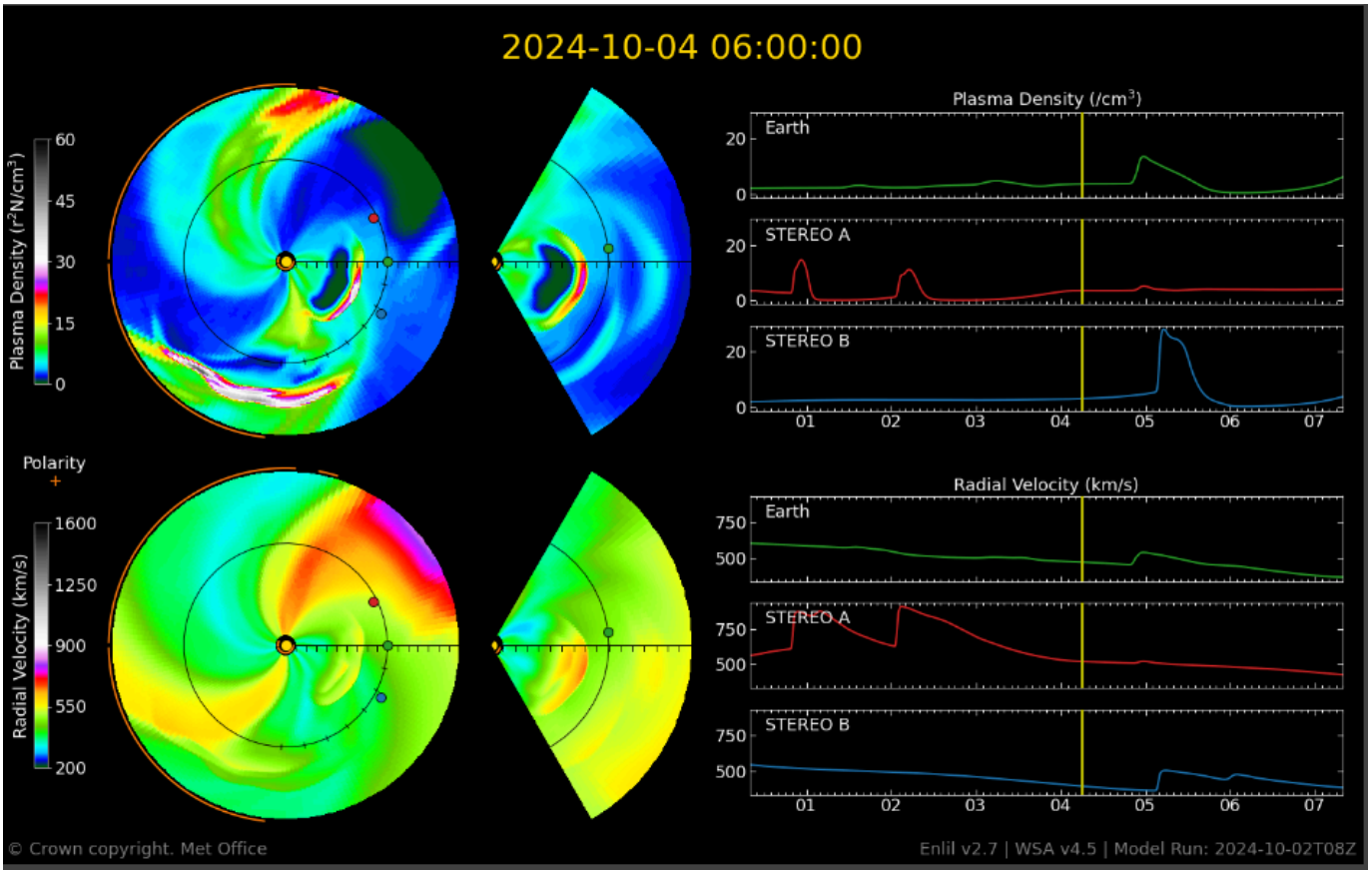
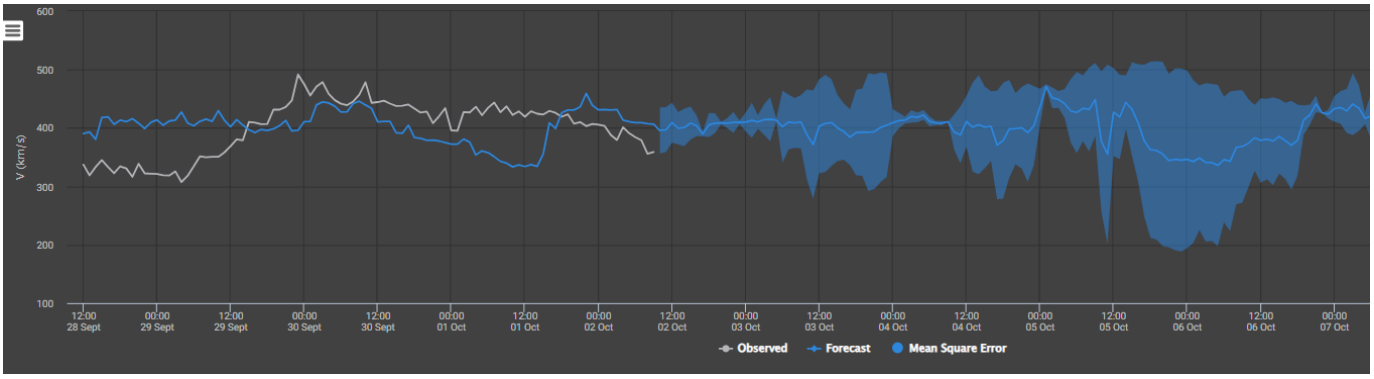


Figure 4: MOSWOC SWPM, considered a reasonable steer Days 1-2. Lower confidence Days 3-4 due to uncertainty in CME arrivals.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Radio Blackouts - X-Ray Flares

Solar activity has been High with a X7.1 from AR3842 and a number of M-class flares in the past 24 hours.

There are currently around thirteen sunspot regions on the visible disc. The most notable remains AR3842 (Ekc/Beta-Gamma-Delta), the largest sunspot group, located in the southeast quadrant but close to the meridian. This region contains at least one delta portion and has exhibited further growth and consolidation of spots within the compact central and leading portions. The next largest region is the newly numbered AR3848 (Dki/Beta) spot rotating into view around the northeast limb, the size remains estimated at present as does the classification with viewing angle severely restricted. AR3841 (Dai/Beta-Gamma-Delta) in the northeast, close to the meridian has shown recent growth and increase in magnetic complexity with two strong delta spots forming on the trailing asymmetric portion. AR3843 and AR3844 in the southwest are also of note, with both Dsi/Beta regions exhibiting further penumbral growth and the proliferation and consolidation of smaller spots. All other spots are smaller and appear relatively benign, including two small and simple regions which have emerged since last analysis.

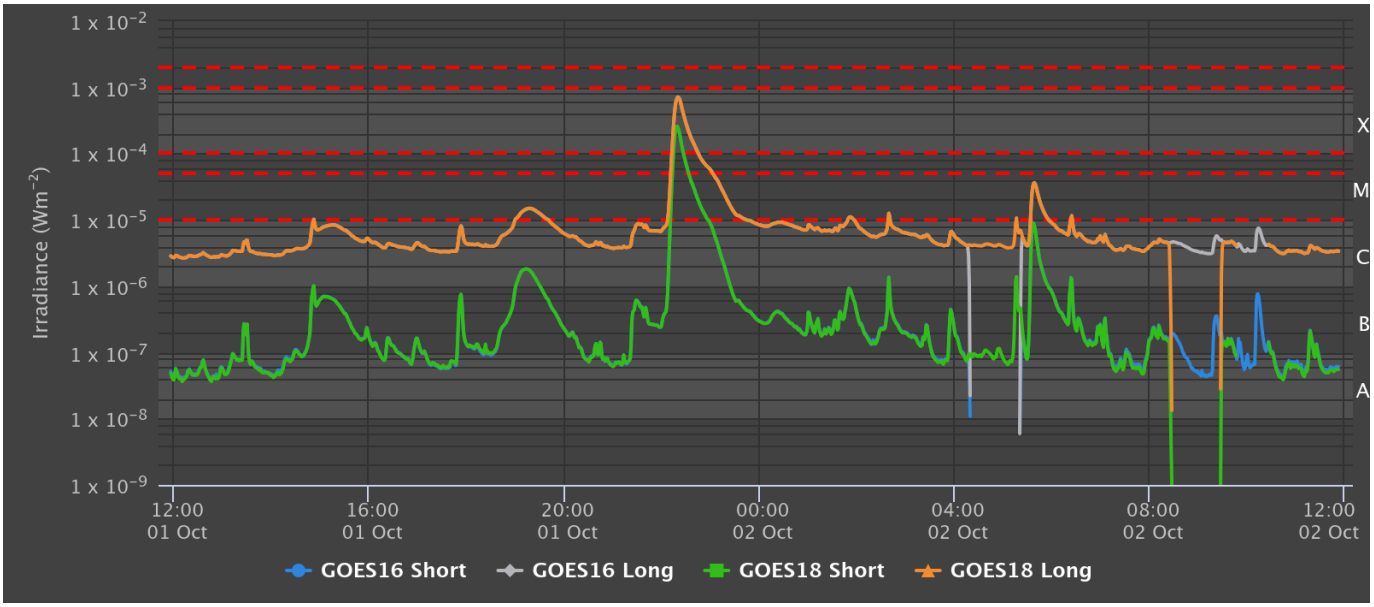
Solar activity is expected to become Moderate, with further M-class flares expected and a chance of returning to High should another isolated X-class flare occur, these most likely originating from AR3842 but also from the increasingly complex and unstable AR3841. The risk may reduce later in the period, mainly due to uncertainties in complexity and longevity of sunspot groups on the disc.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	70	70
Very Active	R3-R5 (X Class)	Yes	30	30	20	20

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 5: GOES16 and GOES18 24hour X-ray trace. Peak of X7.1 at 01/2220 UTC



© Crown Copyright 2024. All Rights Reserved.

Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 is forecast to persist at background levels. No notable proton enhancement was observed following the X7.1 flare and associated CME. There is a continued chance of Proton rich flares, mainly from AR3842, but with notable filaments on the disc also posing a risk should they erupt.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	30	30	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

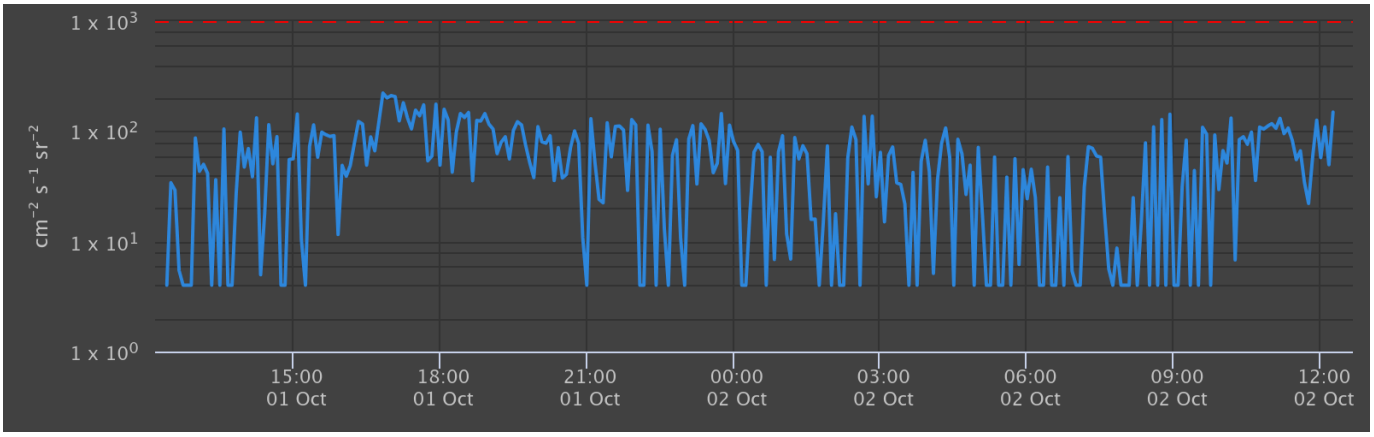
High Energy Electrons (≥ 2MeV)

High energy electron flux (greater than 2MeV) observed by GOES16 was at background to Moderate levels (at diurnal peak). A recovery to Moderate or perhaps briefly High levels (at diurnal peak) is possible towards the end of the period, before the potential influence of a further CME reduces confidence.

The associated 24 hour fluence is forecast to stay below Active (1e8 total pfu), in agreement with MOSWOC REFM, although a slight increasing trend is possible during Day 3 (04 Oct) but is still expected to remain below the Active threshold.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ 1×10^{8}**	No	1	1	10	1
Very Active	**≥ 2 MeV ≥ 1×10^{9}**	No	1	1	1	1

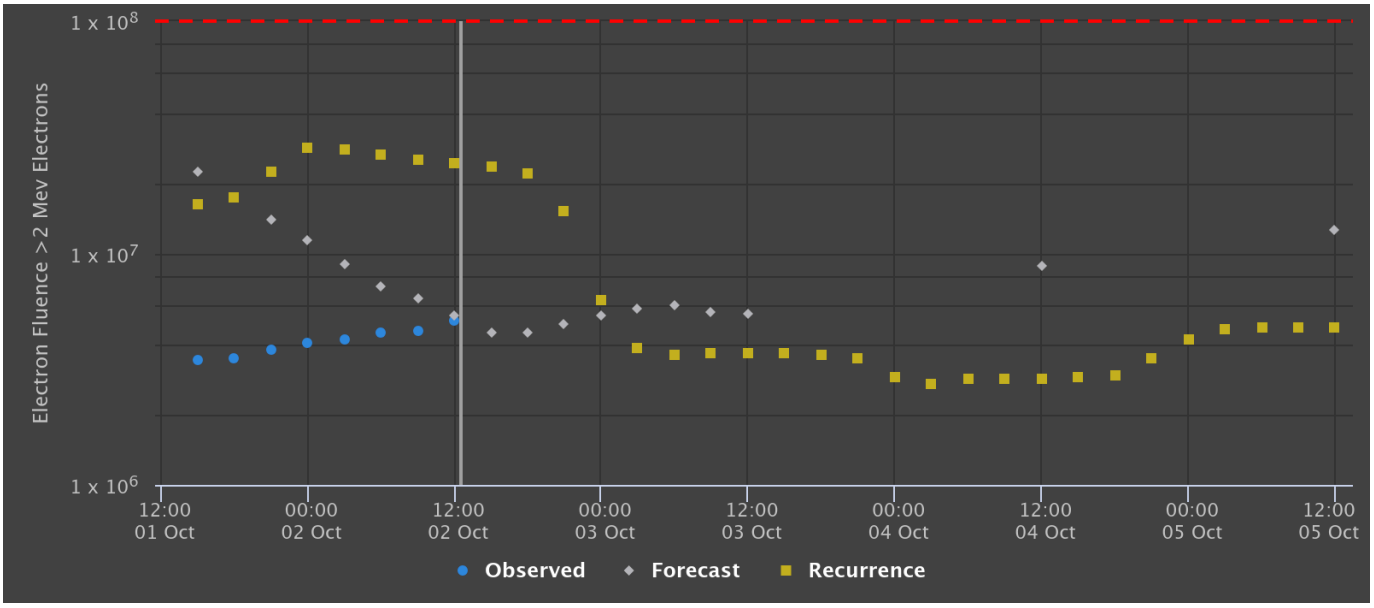
Figure 6: GOES16 Electron Flux trace over past 24 hours



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 7: MOSWOC REFM showing a generally steady forecast for fluence values well below Active.



© Crown Copyright 2024. All Rights Reserved.